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APPLICATION OF GRANULAR HERBICIDES TO ORNAMENTAL PLANT MATERIALS IN NURSERIES 1/

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The application of selective herbicides for the control of annual and perennial weeds in nursery crops is not a new technique.3/ Recently nurserymen have become interested in weed control as a regular practice in the normal sequence of production.

The application of herbicides to nursery crops is complicated by the diversity of plant materials handled by production nurseries. Many of the cultivated crops are related to the weeds to be controlled. Further complicating effective control is the change with maturity in the susceptibility of plant material to herbicides. Some crops are woody and may range from shallow-rooted fibrous plant materials, such as privet and barberry, to plants with only a few large-branched roots, such as crapemyrtle and apples. These may be planted as seedlings, ranging in age from one year to several years, or as container-produced plants, which are considerably older and more mature. Herbaceous perennials offer a challenging problem to weed specialists, since this type of plant material requires a herbicide that can be applied within a relatively wide, safe range of concentrations.

With the emphasis on the production of a quality plant product as well as on ease and economy of production, the nursery industry is

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3/ Curtis, O. F., Jr. Chemical weed control in nursery tree rows. Proc. Amer. Soc. Hort. Sci. 60: 109-116. 1952

particularly interested in chemical weed control.[4/] Application of low cost effective herbicides with one growing season's residual control would be ideal for the average nursery operation. It would be desirable to apply this chemical early in the year, or perhaps the previous fall, when the demand for time and equipment by other operations is at a minimum.

Some of the early work on granular formulations was done on the east coast in connection with the application of granular calcium cyanamid to compost and to seedbeds for turf.[5/] In the years following, the emphasis shifted to the use of liquid formulations of preemergence chemicals.[6/] Since about 1959, many of these chemicals have also been available as granular formulations.

As manufacturers developed granular formulations, it became apparent that one of the major problems was adequate distribution. The manufacturers of granular applicators have found it difficult to solve all the problems of granular application. Continuous flow, metering devices, pulverization of materials in hoppers and resultant production of fines are some of the problems associated with granular applications. In addition, the increased distance necessary between the hopper and soil line as the height of plant material increases complicates application on windy days and further affects the distribution pattern. During 1962 and 1963, however, application equipment was greatly improved. Requirements were determined for preemergence granular herbicide applicators in many crops, particularly corn and soybeans, and equipment was developed for that use. Similar requirements for nursery stock have not been established.

The nurseryman is probably more familiar with the application of granular products to the soil than he is with the application of liquids. The use of a hand-crank-operated seeder for application of fertilizers, the topdressing of lawn areas with granular fertilizers, and similar operations are common. Liquid formulations of insecticides and fungicides have been limited primarily to the aboveground parts of the plant. This procedure has often led to problems when the same equipment was used for the application of herbicides. The decision facing the nursery today is, "Do we shift to granulars?" or "Should we stay with the liquid formulations?"

4/ Anonymous. Recent experiments in chemical weed control. Amer. Nurseryman 108(4): 114-117. 1958.

5/ DeFrance, J. A. Weed-free compost and seed beds for turf. R.I. Agr. Expt. Sta. Misc. Pub. 31: 1-5. 1948.

6/ Mahlstede, J. P. Chemical weed control in the nursery. Amer. Nurseryman 101(8): 11-12, 100-106. 1955.

This decision is particularly important to wholesale growers who are having to purchase new equipment. Although there is no clear-cut "yes" or "no" answer to fit all types of operations and situations, it would be valuable to consider the following advantages and disadvantages of granular herbicides.

ADVANTAGES OF GRANULAR FORMULATIONS OF HERBICIDES FOR NURSERIES

Advantages of granular formulations of herbicides for nursery weed control:

- Ease of Application

  Since distribution is based on free-flow, little agitation is necessary other than to maintain uniformity of depth throughout the hopper. The equipment is simple and not so subject to leaks, plugging, and similar mechanical failures that are common with sprayers. There is no vaporization; thus skin and eye irritation is reduced. Equipment is lightweight.

- Ease of Handling

  No mixing or measuring is required. Necessity for water is eliminated; thus widespread application in separated areas is possible.

- Selectivity

  Established and recently transplanted crops are less subject to injury at a given concentration than from a liquid concentration of a solvent.

- Increased Period of Activity

  A given chemical on a granular particle may be active longer than a chemical applied as a liquid, as it is less readily leached. The length of the activity depends on rainfall and other environmental conditions.

- One-Shot Application

  Since visual patterns can be recognized, overlapping and skips are minimized.

- Ease of Combination

  Mixing with dry formulations of soil insecticides and fungicides is possible when granular herbicides are used.

- Reduction in Drift Injury

  Since the chemical is applied in the dry state, danger of plant injury by volatile chemicals is reduced.

DISADVANTAGES OF GRANULAR FORMULATIONS OF HERBICIDES FOR NURSERIES

Disadvantages of granular formulations of herbicides for nursery weed control:

- Expense

  As granular formulations are purchased in the ready-to-use state, transportation cost of the carrier has to be paid.

- Calibration Difficulty

  Commercial equipment available for application is based on gravity-feed mechanism. Considerable variation between products necessitates calibration for each product. Speed of the equipment is very important in determining rate, and, consequently, limits might be set by the type of tractors available.

- Uniformity

  Since large particles are being applied, uniform application on nursery rows that are uneven because of recent planting or cultivation is difficult.

- Inexperience

  The terms "constant speeds" and "calibration" are new to many nurserymen and further complicate the acceptance and effective use of this group of herbicides.

- Increased Equipment Inventory

  Type of equipment required to apply granular formulations of herbicides is specialized and may not be adapted for other cultural operations carried on by a typical nursery.

- Activation

  Activation of the chemical and its distribution from the granular particle are modified by soil moisture. If the chemical is placed on a dry soil surface and not worked into the soil, residual problems and lack of activity may become a problem.

- Umbrella Effect

  Application of the granular particle over the entire soil surface is necessary for adequate control. Many broad-leaved and narrow-leaved evergreens interfere with the distribution pattern, which makes uniform distribution difficult, particularly under and immediately adjacent to the plant and between plants in the row in older stock.

- Equipment Limitations

Although granular-application equipment is available for soil insecticides and preemergence herbicide applications, as well as for the control of corn borers, there has been little or no equipment specifically developed for applying granular herbicides to nursery stock in the field.

The equipment limitation for the distribution of granular herbicides, therefore, represents a major consideration for nurserymen contemplating a complete chemical weed control program. Row spacings used in cultural programs have often been changed to conform to available applicator widths. After several years of growth, specimen plant materials limit accessibility and preclude economical use of a given land area.

METHODS AND MATERIALS

The objectives of this study were (1) to evaluate experimental granular application equipment that could be commercially developed; (2) to compare the effectiveness of granular and liquid formulations of herbicides; (3) to evaluate, in terms of weed control, the effects of various rates of granular herbicide formulations when applied to upright and spreading nursery stock of different ages; and (4) to evaluate the effect of liquid and granular herbicide formulations on plant materials with different growth habits.

Each plot contained 150 square feet. A randomized block design with 10 replications was used. The age of plants changed, but the general layout remained the same throughout the course of these studies. The weed-control effectiveness of all herbicides used in these experiments was based on weed counts and density-stand estimates. Three random, 1-square-foot weed counts were averaged with an overall estimate of weed density. A heavy weed density (30 percent and over) corresponded to a weed population that would require mowing, rototilling, and hoeing to remove adequately the weed population from the plot; a medium weed density (11 to 29 percent) corresponded to an infestation that could be removed economically by summer weeding crews; and a light density stand (0 to 10 percent) corresponded to commercial control necessitating only infrequent cultivation. A light density rating, such as 10 percent, would be equivalent to 90 percent weed control.

In general, herbicide applications were made in April to weed-free plots (fig. 1). These plots were evaluated between the middle of June and the first of July; the time depended on the amount of rainfall and subsequent weed growth during the spring months (table 1). Repeat applications of the more promising chemicals were applied to assigned plots and to those sprayed previously with closely related chemicals or those having similar residual qualities.

Figure 1.-- The pull-type applicator being used to apply granular herbicides to spreading junipers.

Application of liquid formulations were made with a knapsack sprayer at 40 gallons per acre. The entire soil surface of the plot area was covered with the spray, under the plants as well as over them. Granular formulations were applied in 1959, 1960,and 1961 with a 5-foot gravity-feed granular applicator drawn at a constant speed over the plants in the row. In 1962, a powered, high-clearance granular applicator was used to apply the herbicides over the top of the plants (fig. 2).

TABLE 1.-- Temperature and rainfall data, Ames, Iowa, 1959-62

Date[1/]	Maximum soil temperature (1-inch depth)	Rainfall
	°F.	Inches
1959		
Apr. 9	57	0
Apr. 10	56	0
Apr. 11	56	0
Apr. 12	47	0
1960		
Apr. 28	61	.04
Apr. 29	56	.49
Apr. 30	55	.63
May 1	66	.30
1961		
Apr. 13	50	0
Apr. 14	51	.08
Apr. 15	45	0
Apr. 16	41	.02
1962		
Apr. 25	74	0
Apr. 26	75	0
Apr. 27	71	.15
Apr. 28	62	.08

1/ First date in each year was the date of application.

RESULTS

Liquid and granular formulations of simazine (2-chloro-4, 6-bis(ethylamine)-s-triazine), applied at 3 lb. per acre on April 9, 1959, resulted in 94 percent control of broad-leaved and narrow-leaved weeds over a 70-day period. CIPC (isopropyl N-(3-chlorophenyl) carbamate), at 8 lb. per acre, gave 89 percent control; EPTC (ethyl N, N-di-n-propylthiolcarbamate), at 8 lb. per acre, 83 percent; and CDAA (2-chloro-N, N-diallylacetamide) at 4 lb. per acre, 44 percent control in this same experiment. The plots were then handhoed and allowed to remain until September 19, when they were again evaluated on the basis of the weed population. The residual properties of simazine were evident in the 90 percent control afforded by this chemical in all plots (fig. 3). The control of weeds varied considerably for the liquid and granular formulations of the other chemicals. A

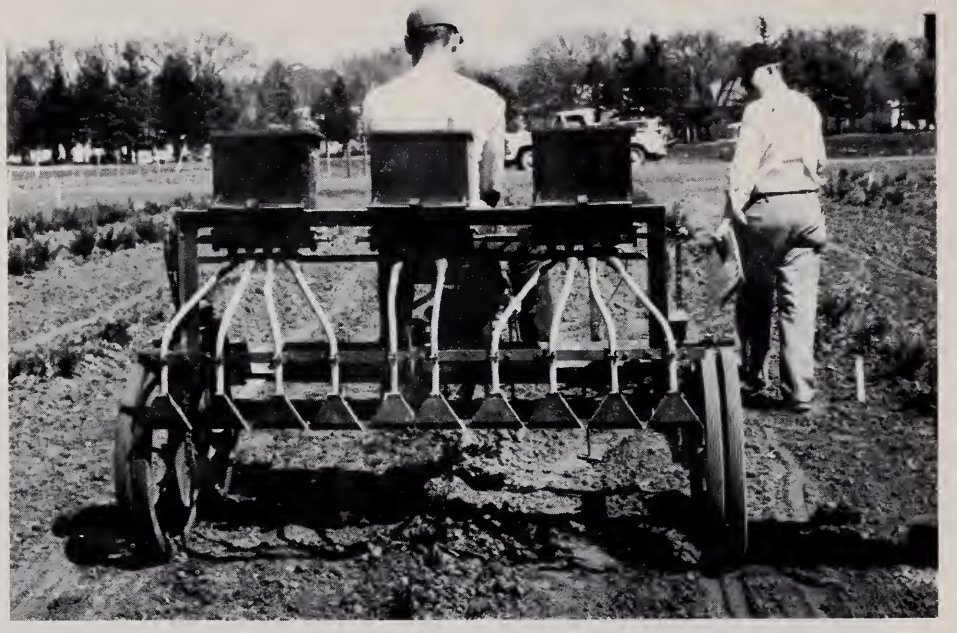

Figure 2.-- The self-propelled applicator being used to apply granular herbicides to young upright taxus.

comparison between liquid and granular herbicides was made in 1959 only. Results indicated that little or no difference existed between the two methods of application.

An evaluation of the experimental equipment used indicates that the hoppers, spreaders, and metering devices used for other granular herbicide applications could be used for nursery stock if provisions are made for adequate plant clearance.

Experiments conducted from 1960 to 1962 compared only the chemicals available as granular herbicides and those that would fit into the sequence of nursery weed control programs.

On April 28, 1960, nine chemicals were applied in granular form to 1- and 4-year (in the field) taxus and junipers. The commercial control, based on the density of weeds per plot on July 1, varied considerably for the type of plant material. Table 2 shows weed control from five of the chemicals used. All other chemicals resulted in less than 65 percent control.

Figure 3.--Typical control obtained with granular simazine.

The average control for all chemicals was 40 percent in the two age groups of junipers and 75 percent in the two age groups of taxus. This was the first indication that the habit of growth of plant materials affected the pattern and final disposition of the granular particles. Some evidence of chlorosis and epinasty was observed where CDAA + TCBC was used on taxus plants.

In 1961, only those chemicals that had generally shown promise in preceding years were tested. Simazine, 3 and 6 lb. per acre; the ammonium formulation of atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-trazine), 3 and 6 lb. per acre; CDAA + TCBC (2-chloro-N, N-diallylacetamide, trichlorobenzyl chloride), 4 lb. per acre; dichlobenil (2,6-dichlorobenzonitrile), 3 and 5 lb. per acre; and amiben (3-amino-2, 5-dichlorobenzoic acid), 3 lb. per acre; were applied on April 13, 1961, to weed-free plots containing the two types of plants used the preceding year. The effectiveness of the specific herbicide was again influenced by the habit of growth. Table 3 shows the weed control obtained between plants in the row with six of the chemicals used. The other compounds had less than 70 percent control.

TABLE 2. -- Percentage of weeds killed by granular herbicides, as affected by habit of growth and age of crop plant, 1960[1/]

(Chemicals applied Apr. 28, 1960; evaluated July 1,1960)

Granular Herbicides[2/]	Juniper (Spreading; heavy shade)		Taxus (upright; medium shade)	
	1-year	4-year	1-year	4-year
	Percent	Percent	Percent	Percent
atrazine (6)	65	< 65	97	88
CDAA + TCBC (4)	83	75	91	86
dichlobenil (3)	71	66	< 65	82
simazine (3)	< 65	< 65	86	< 65
2,4-D (3)	< 65	75	87	< 65

1/ Herbicides listed are those that controlled at least 65 percent of weeds, compared with check plots without herbicides.

2/ Figures in parentheses after the chemical name are the pounds per acre of active ingredient.

The effectiveness of granular applications of dichlobenil was consistent with that obtained the previous year (fig. 4). All chemicals, averaged for all concentrations in plots containing these older plant materials, gave 78 percent weed control to July 1 in the juniper plantings and 52 percent control in the taxus plantings. Again in 1961, the taxus treated with CDAA + TCBC showed damage.

Repeat applications of these chemicals, together with two new potential nursery herbicides, were made in 1962. Simazine and atrazine, 3, 6, and 12 lb. per acre; CDAA + TCBC, 4 and 8 lb. per acre; DCPA (dimethyl-2,3,4,6-tetrachlorotcrephthalate), 8 and 16 lb. per acre; and dichlobenil, 4 and 8 lb. per acre, were applied in granular form to each of spreading junipers and upright taxus. The effectiveness of the weed control between plants in the row was measured. Only those treatments which resulted in 45 percent weed control or above for one or more plant invironments are included in Table 4.

Figure 4.-- Typical control obtained with granular dichlobenil.

In general, the high rates of application resulted in the best weed control. The chemicals were more effective in the plantings containing smaller stock. There were no visual symptoms of injury with any chemical or concentration with the exception of CDAA + TCBC at the 4- and 8-lb. per acre rates. Consistent with results from previous years, all rates of this chemical resulted in chlorosis and epinasty on taxus foliage. Untreated check plots, such as the one shown in figure 5, were used to determine the percentage control obtained by the various chemicals used.

DISCUSSION

The considerable variation in the effectiveness of the various chemicals and concentrations in these experiments suggests that further work is needed to determine the influence of soil temperature, soil moisture, particle sphere of influence, distribution patterns, and the umbrella effect of different types of plant materials on weed-seed germination and development.

TABLE 3.--Percentage of weeds killed by granular herbicides, as affected by habit of growth and age of crop plant, 1961[1/]

(Chemicals applied Apr. 13, 1961; evaluated July 2, 1961)

Granular herbicides[2/]	5-year juniper (spreading; heavy shade)	5-year taxus (upright; medium shade)
	Percent	Percent
amiben (3)	95	70
CDAA + TCBC (4)	88	< 70
dichlobenil (3)	80	70
dichlobenil (5)	85	88
$NH_4^{\wedge}$ atrazine (6)	75	90
simazine (6)	71	70

1/ Herbicides listed are those that controlled at least 70 percent of weeds, compared with check plots without herbicides.

2/ Figures in parentheses after the chemicl name are the pounds per acre of active ingredient.

The fact that similar control patterns were obtained for liquid and granular formulations of several herbicides in relatively small nursery stock suggests that effective control can be obtained with granular formulations in relatively young stock, particularly if upright in habit. This observation is supported by the results obtained in 1960 when commercial control was obtained from the use of most granular herbicides in plots containing Taxus cuspidata capitata and Taxus media hicksii. A light, steady rain facilitated herbicide release from the granules without dislocating the in-place particle. It was also significant that granular 2,4-D could be used without injury in established narrow-leaved evergreens of the type used in these experiments.

In 1961, distribution patterns were influenced by wind gusts during the application sequence. Wind, together with a light rain immediately after application, dislodged particles on the plants and on the soil surface. This, in turn also may have influenced herbicide-distribution and subsequent weed-population patterns.

TABLE 4.--Percentage of weeds killed by granular herbicides, as affected by habit of growth and age of crop plants, 1962[1/]

(Chemicals applied Apr. 25, 1962; evaluated July 1, 1962)

Herbicide[2/]	Juniper (spreading)		Taxus (upright)	
	3-year	6-year	3-year	6-year
	Percent	Percent	Percent	Percent
atrazine (3)	< 45	< 45	82	< 45
atrazine (6)	< 45	64	< 45	< 45
atrazine (12)	94	76	82	51
CDAA + TCBC (8)	< 45	< 45	96	< 45
DCPA (8)	< 45	< 45	81	< 45
DCPA (16)	90	< 45	< 45	< 45
dichlobenil (4)	< 45	60	< 45	< 45
dichlobenil (8)	90	< 45	< 45	< 45
simazine (6)	< 45	84	< 45	50
simazine (12)	86	< 45	< 45	52

1/ Herbicides listed are those that controlled at least 45 percent of weeds, compared with check plots without herbicides

2/ Figures in parentheses after the chemical name are the pounds per acre of active ingredient.

At the time of application in 1962, the soil was relatively dry, and higher rates of the chemicals in this series of tests generally were more effective than the lower concentrations. The umbrella effect of the older, spreading junipers modified the effectiveness of the herbicide between plants in the row. This is understandable, since stock of this type and age forms a relatively tight canopy over the soil surface. The microenvironment under and on the north side of these plants as it applies to the

evaporation of moisture from the soil surface during the early spring may be another important consideration affecting ultimate herbicide performance.

It is apparent from these results that an overall application of granules over the top of nursery stock resulted in adequate weed control when effective chemicals were used. Application equipment requirements are the same as for other herbicide applications except for plant clearance and row spacing. These are minor problems that can be easily overcome by the equipment industry.

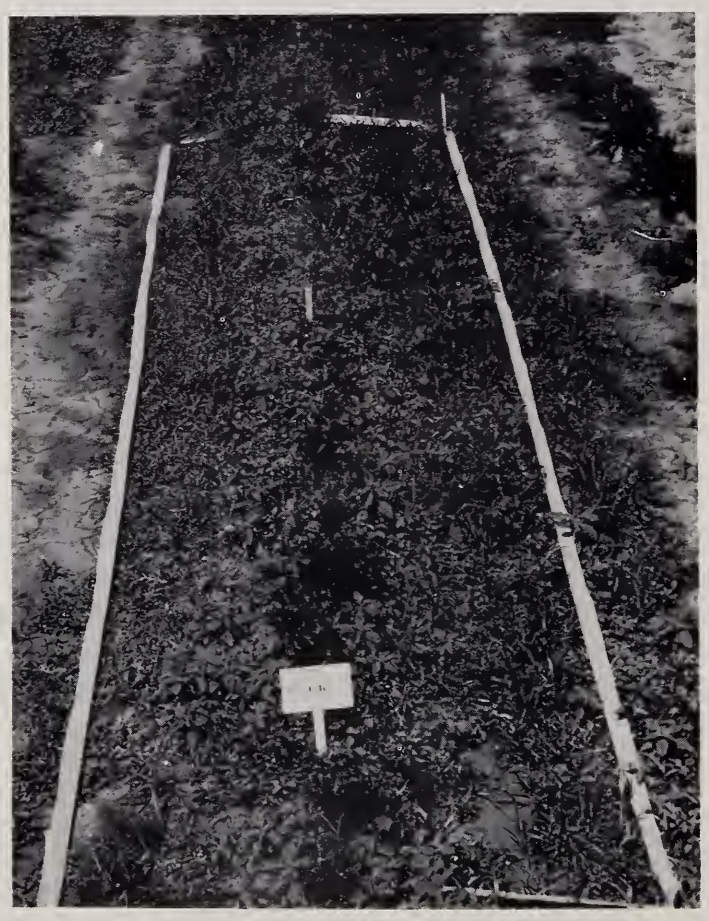

Figure 5.--A typical untreated check plot that contained both grass and broad-leaved weeds.

SUMMARY

Under optimum conditions of environment, the effectiveness of simazine, CIPC, CDAA, and EPTC applied in liquid and granular formulations were similar.

Application of granular formulations of various herbicides and subsequent control was influenced by the age and habit of growth of the crop plant. Conditions of the microenvironment are also believed to play a critical role in chemical availability, as integrated with seed germination, seedling emergence, and seedling development.

Although no one chemical consistently gave commercial weed control, dichlobenil at 3 and 5 lb. per acre approached this criterion.

Simazine and atrazine at the 12-lb. rate did not affect the growth and performance of established taxus and junipers during the 1962 growing season.

CDAA in both the liquid and granular formulations resulted in chlorosis and epinasty of the foliage of taxus, regardless of age of the plant or concentration used.

Continued investigations are warranted with this type of plant material to investigate the influence of microenvironment on release of chemicals, seed germination, and seedling development.

The basic hoppers, metering and spreading devices that are commercially available, resulted in adequate weed control when the granules were spread over the top of the plants. However, it may be possible to improve control with a directional type of application.

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